Part 1 - Summary Details

CRDC Project Number: **CRC47**

Project Title: Quantifying deep drainage using lysimetry

Project Commencement Date: **Project Completion Date:** 2005

CRDC Program: On Farm

Part 2 – Contact Details

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Part 3 – Final Report Guide (due 31 October 2008)

Background

1. Outline the background to the project.

Objectives

The original project timetable was revised to reflect the late start of the project caused by the third party agreement for CSIRO Land and Water to carry out this project on behalf of the Cotton CRC not being signed until 1 December 2003, which in turn delayed appointment of a technical officer until April 2004.

Objectives Year 1 (July 2003 – June 04, revised to April 2004 – March 2005):

- *Survey and characterise selected site for lysimeter.* A plot in Paddock C1 at ACRI under cotton-wheat was chosen after consultation with interested parties. The location was deemed to be reasonably typical of Vertosols used for irrigated cotton. A rotation was chosen because it would give a wider range of soil water conditions for drainage measurements. A site investigation was carried out in June 2004, and samples were taken to 2 m depth. The saturated and unsaturated hydraulic conductivity together with water release properties, particle size distribution, and soil chemical properties of these samples were measured. In addition, an EM survey of the field was carried out by Tim Weaver (ACRI), which we used to ensure the lysimeter is not located in any patches of anomalous soil.

- *Construct first lysimeter cell.* The equilibrium tension lysimeter (Brye *et al.*, 1999, Soil Sci. Soc. Am. J. 63:536-543) was chosen to measure drainage because of its 'hydraulic invisibility'. The trays are installed via a horizontal tunnel from a concrete access shaft similar to those used by NSW DPI at Breeza near Gunnedah.

  During 2004/05 considerable effort has been put into designing both the access shaft and the lysimeter collection trays. The access shaft was designed to allow irrigation water to flow unimpeded above it. It consists of a 2 m diameter by 3.5 m deep cylinder of reinforced concrete, with a lid and floor. It was installed in a 4 m deep hole drilled by a bucket drill, so that the lid is 0.5 m below ground surface. A metal hatchway, 0.6 × 1.1 m in cross-section and 0.6 m tall, connects the concrete lid to the surface to allow access down a ladder. A guard rail can be attached to the hatchway when it is open as a safety measure. The lid and hatch are designed not to interfere with tillage operations or the flow of irrigation water. The access shaft and hatchway meet safety regulations and were approved by a structural engineer. The area above the lid was backfilled with soil after first installing a drainage system. This removes any excess water that infiltrates above the lid to prevent it 'spilling' over the side of the well and increasing the water content of the surrounding soil. It consists of plastic sheet round the circumference of the lid, with slotted drainage pipe running round its inside and backfilled with gravel. The pipe then travels down a sloping trench (to the west) of the well to a gravel filled sump. The access well was installed in September 2004.

  The collection trays were designed and six trays manufactured by CSIRO workshops in Canberra. They will accurately measure drainage from an area of over 1.5 m^2 in total by applying a vacuum equal to the soil water potential in the surrounding soil, which ensures

that the hydraulic gradient at the installation depth (2 m) is the same as that in the surrounding soil. Each tray consists of a 900 × 280 × 120 mm stainless steel box open on the upper surface. The surface is crossed by bars to support a sintered stainless steel sheet about 1 mm thick which allows water to pass through, but can hold a vacuum of up to -28 kPa once saturated. The trays are pressed against the soil ceiling of the tunnel using air-jacks. A contact material consisting of silica flour with the particle less than 20 μm removed was designed and manufactured. The properties of the porous steel plate and the contact material were tested to ensure that the system can handle the flux of drainage water arriving at the tray without slowing it. In addition a system for excavating the tunnel was designed and tested along with a method of preparing the ceiling using an epoxy resin peel to make sure the clay is not smeared. The first two trays were installed in May 2005.

During the design phase a more accurate costing for the lysimeter was developed, which was greater than that budgeted originally. In consultation with CRDC, it was decided that the best way to have a properly functioning and instrumented facility would be to build only one access well with six collection trays.

- *Purchase and install equipment for parallel measurement of drainage and measurement of other components of the water balance.* A weather station for installation near the lysimeter has been arranged along with irrigation advance detectors. Neutron probe access tubes have been installed to allow regular monitoring soil water and Echo probes will be installed to allow continuous, albeit less accurate, soil water monitoring. Collaboration with other researchers allowed installation of 4 barrel lysimeters – a less expensive way of measuring drainage – in the same plot as the equilibrium tension lysimeter during May 2005 by Queensland NRM. Resistivity imaging by University of Technology Sydney will be conducted regularly to produce 2-D images of water content in the soil profile along 30 m transects. Later in 2005 long-stop wetting front detectors will be installed by CSIRO Land and Water as a potential technology to allow irrigators to understand the fate of irrigation water during application and thereby improve irrigation practice.

The remaining objectives will be met in coming years.
Objectives Year 2 (2004 – 05, revised to April 2005 – March 2006):
- *Monitor drainage, water balance and water quality under conventional irrigated cotton production.*
- *Ensure measurements allow closure of the water balance*
- *Compare estimates of drainage made by alternative methods.*
- *Construct second lysimeter cell*

Objectives Year 3 (2005-06, revised to April 2006 – March 2007):
- *Initiate monitoring drainage, water balance and water quality under two management systems to provide estimate of sensitivity of drainage to management.*

Methods

2. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research.

Results

3. Detail and discuss the results for each objective including the statistical analysis of results.

Outcomes

4. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

5. Please describe any:-
   a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);
   b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and
   c) required changes to the Intellectual Property register.

Conclusion

As the project is still in the construction phase it has not yet produced any research results. However, the careful design of the facility should mean that accurate drainage measurements will be made in coming years, which enable a better understanding of the conditions leading to drainage and the development of management systems to minimize it. Collaboration with other researchers has also ensured the lysimeter results will used to determine the performance of other technologies that will enable drainage to be measured for more locations.

Extension Opportunities

6. Detail a plan for the activities or other steps that may be taken:
   (a) to further develop or to exploit the project technology.
   (b) for the future presentation and dissemination of the project outcomes.
   (c) for future research.

Publications

RINGROSE-VOASE A.J. 2004. Water Balance and deep drainage under irrigated cotton. In WaterPak (Eds H Dugdale, G Harris, J Neilsen D Richards, G Roth, D Williams) pp. 17-28. (Cotton Research and Development Corporation: Narrabri, New South Wales)

Part 4 – Final Report Executive Summary

Deep drainage of water from below the root zone is the most elusive component of the water balance to measure. Attention on drainage has increased because of concerns both about the efficiency with which irrigation water is used and about environmental damage caused by excess drainage through waterlogging, salinity and the movement of agrochemicals into waterways. However, most work on drainage has either used indirect measurements based on calculation of fluxes from the soil water profile measurements, chloride mass balance, or modelling to estimate its magnitude. This project attempts to directly measure drainage under an irrigated cotton system at ACRI using an equilibrium tension drainage lysimeter modified from a design of Brye *et al.* (1999).

The lysimeter consists of six trays installed at 2 m depth which collect drainage over 1.5 m^2. The trays are stainless steel boxes (900 × 300 × 120 mm high). The top surface is made of sintered stainless steel which is porous and transmits water. The floor of the box slopes to one corner where drainage water can exit into a container. There is another port through which a vacuum is applied.

The trays are installed via a horizontal tunnel projecting from the side of a 2 m diameter × 4 m deep concrete access shaft. The trays are pressed up against the ceiling of the tunnel using air jacks to support the weight of soil. Contact between the porous metal plate and the ceiling is via silica flour from which particles less than 20 μm have been removed to prevent them blocking the plate.

Equilibrium tension lysimeters attempt to be 'hydraulically invisible' by applying a vacuum equal to the soil water potential (suction) in the surrounding soil, as measured by a pair of tensiometers. As the potential changes the vacuum is adjusted by means of a control program in a datalogger. Thus the system maintains the hydraulic gradients found in the soil. This differs from many lysimeter designs that are 'free draining' and, in fact, collect water in the soil at the base of the lysimeter until the soil becomes saturated, which is not necessarily the condition in the surrounding soil.

In addition to the collection trays, the facility includes two vertical arrays of tensiometers; one of 'Echo probes'; four neutron probe access tubes and a weather station. A siphon meter and wetting front detectors will be used to measure the amount of irrigation water entering the furrow above the lysimeter.

The lysimeter was installed in May 2005 in a cotton-wheat system in a Grey Vertosol typical of the soils used for cotton production in the Namoi area. It has about 60% clay to 1.4 m depth with about 25% sand. Below this the clay content decreases to 50% at 2 m depth, with sand increasing to 30%. The exchangeable sodium percentage increases from <2% at the surface to 6% at 2 m depth.

The lysimeter facility has three objectives. The first is to measure drainage and better understand when it occurs during the crop rotation. The second is to act as a benchmark against which to test other, less expensive methods of measuring or estimating drainage which can be used in many more locations. Finally, data from the facility will be used to improve water balance models that can be used in conjunction with farming systems models to estimate drainage at a range of locations over long time periods (decades) and under a range of management systems. Such models can then be used to design more efficient and environmentally benign irrigation systems.